

# High Speed Tank Inspection Tool

## Sonic Sensors

San Luis Obispo, California

[www.sonicsensors.com](http://www.sonicsensors.com)

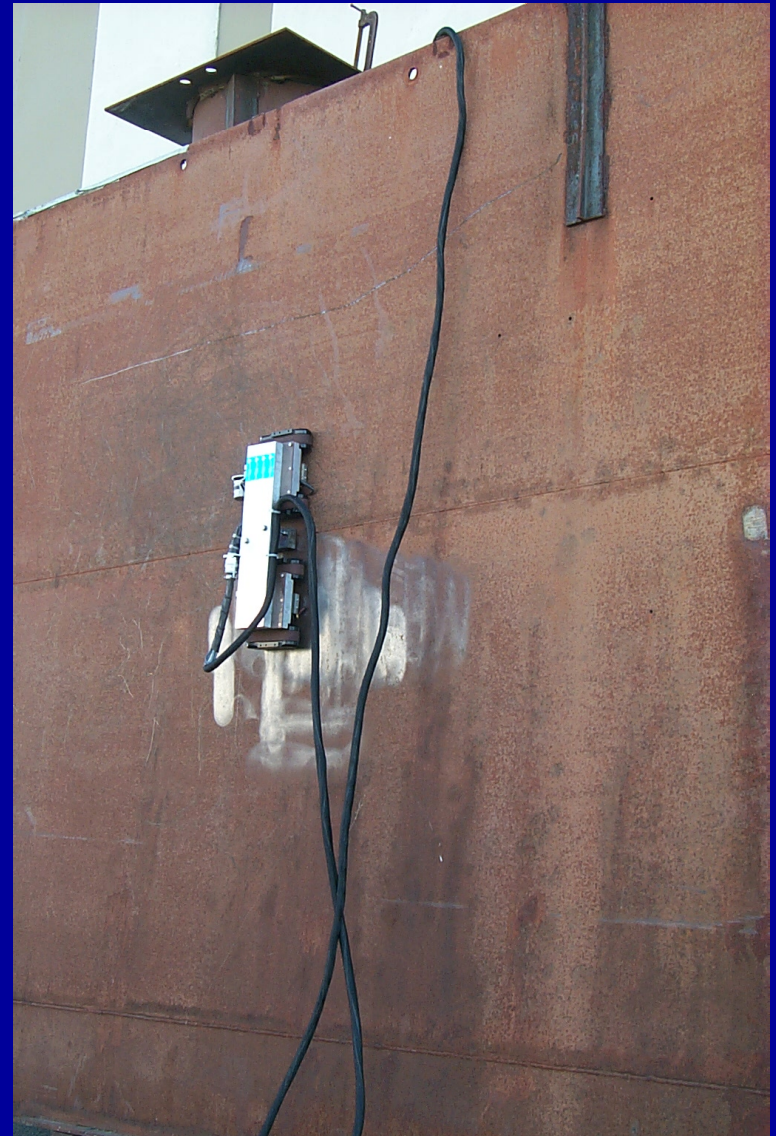
Ron Alers

President of Sonic Sensors

25 August 2009

# High Speed Screening Tool proven at PNNL Tank Mock-Up

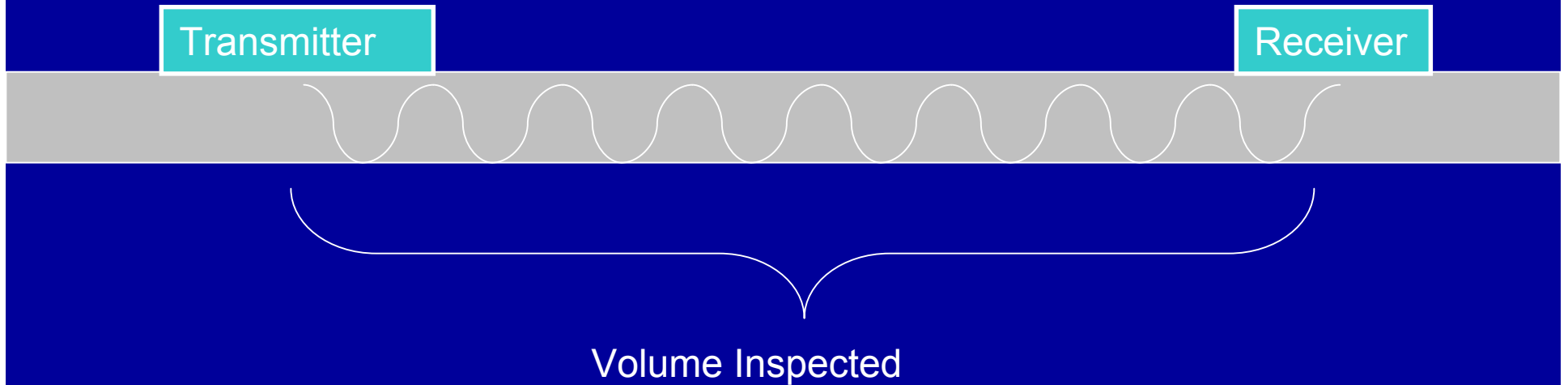
- EMAT Crawler
- Dry (No Water)
- Large Area Screened
- >  $\frac{\text{Square Foot}}{\text{sec}}$
- Thickness Gage can be added
- "P" Scan Compatible



# High Speed = Large Area

- Lamb Wave can travel long distance
- Inspect area between two transducers
- Through Transmission offers high sensitivity

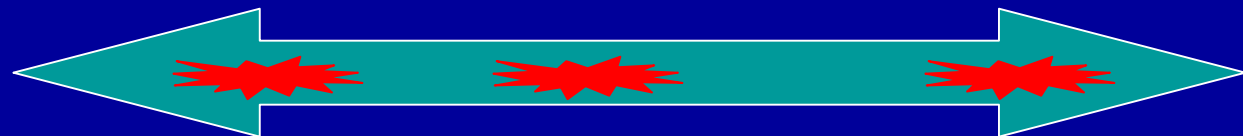
# Lamb Wave Inspection



- High Volume = High Speed
- Large Area covered in a single scan

# High Speed Screening

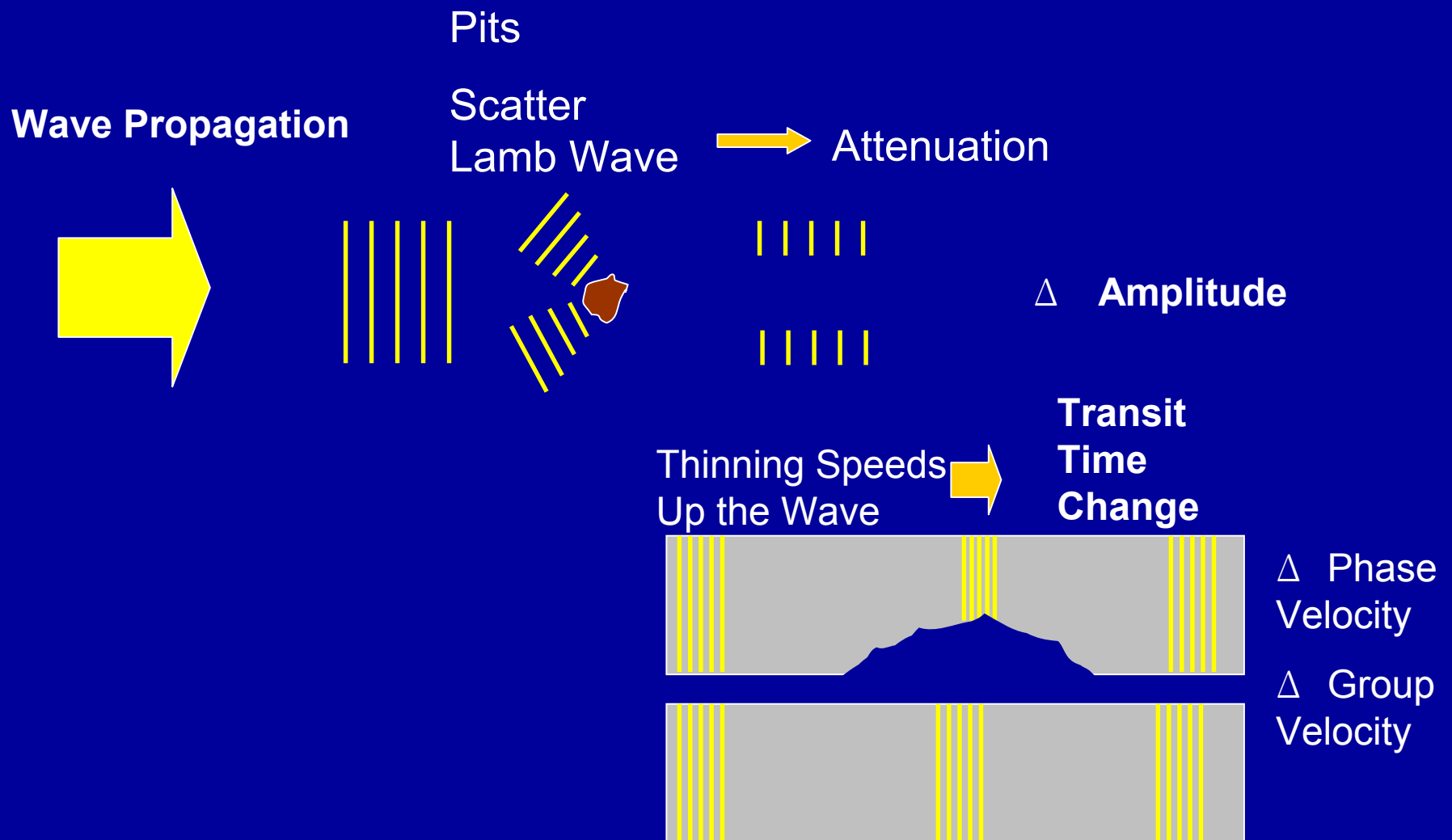
- Volumetric Inspection  
General Corrosion has large effect
- Isolated Pitting has small effect
- Large Distance between transducers  
Possible
- Corrosion Severity determines maximum  
transducer distance



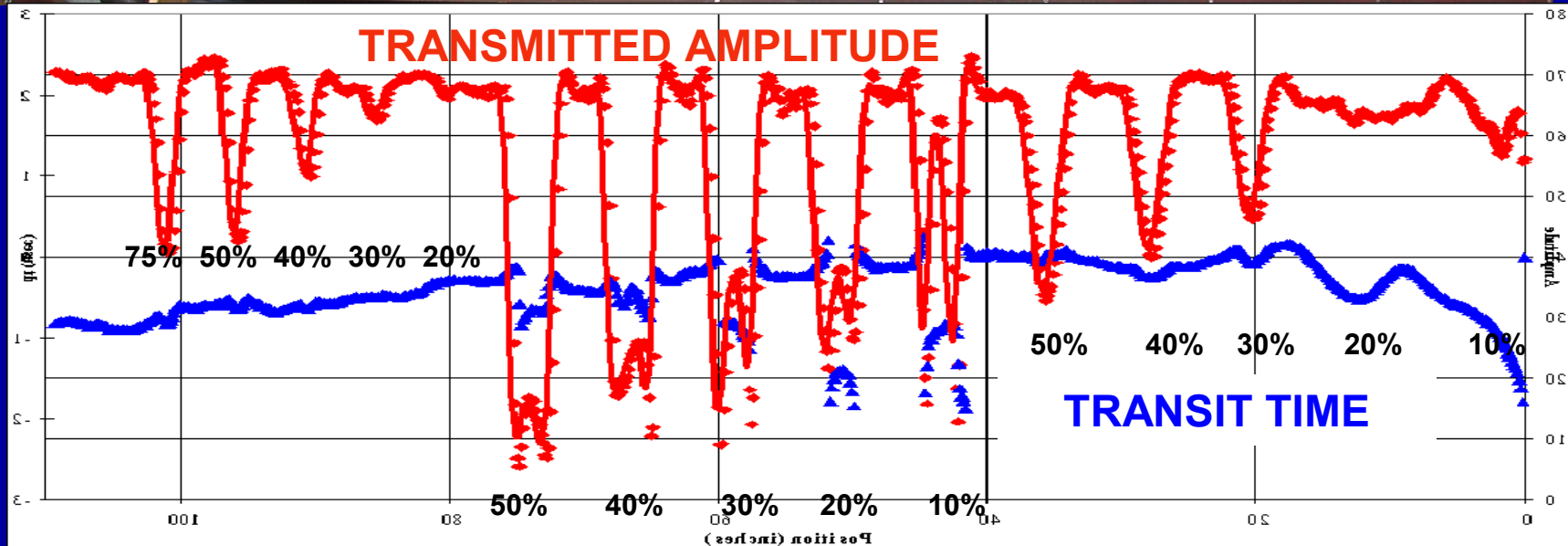
- Sensitivity increases with shorter transducer  
distance



# Geometry Affects Lamb Wave



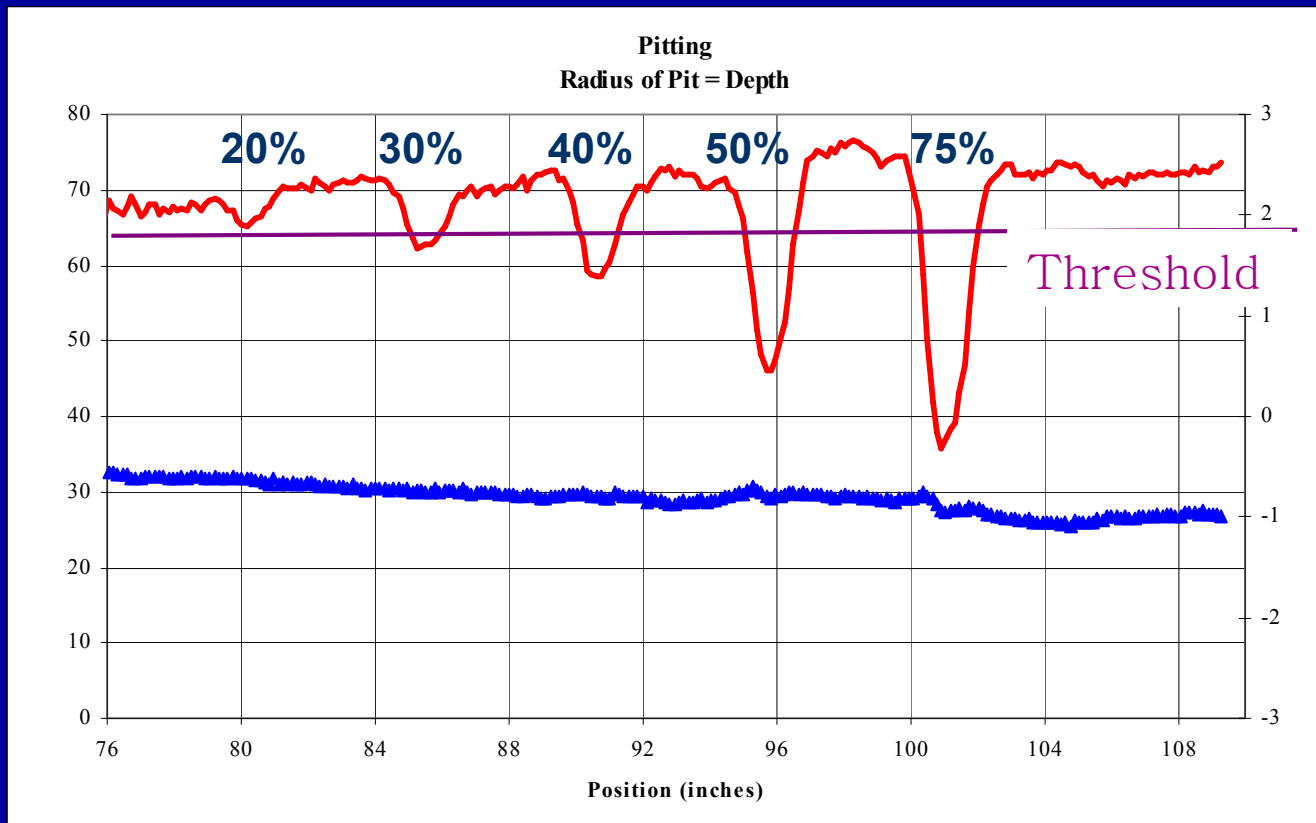
# Calibration Plate



# Feature Identification

- Amplitude change shows beam disturbance:
  - Isolated Pit
  - Steep sided shape
- Velocity (time) change shows Volume loss
  - General Corrosion, wall loss
- Velocity change + Amplitude change
  - Thinning and pitting
  - Wall loss with coarse features

# Qualification for Pitting



# Detection Sensitivity Adequate for Pits at 13" Path Length

- Pitting detected by amplitude change
- Specification
  - Min Reportable Pit @25%
  - Rejectable Pit = 50%
- 6:1 Signal to Noise for 50% pit
- S/N depends on nominal condition

# High Sensitivity to Thinning

- Thinning makes the guided wave speed up.
- 10% thinning clearly evident
- Velocity absolutely confirms volume loss, Reliable Inspection

# PNNL Double Wall Storage Tank Mock-Up

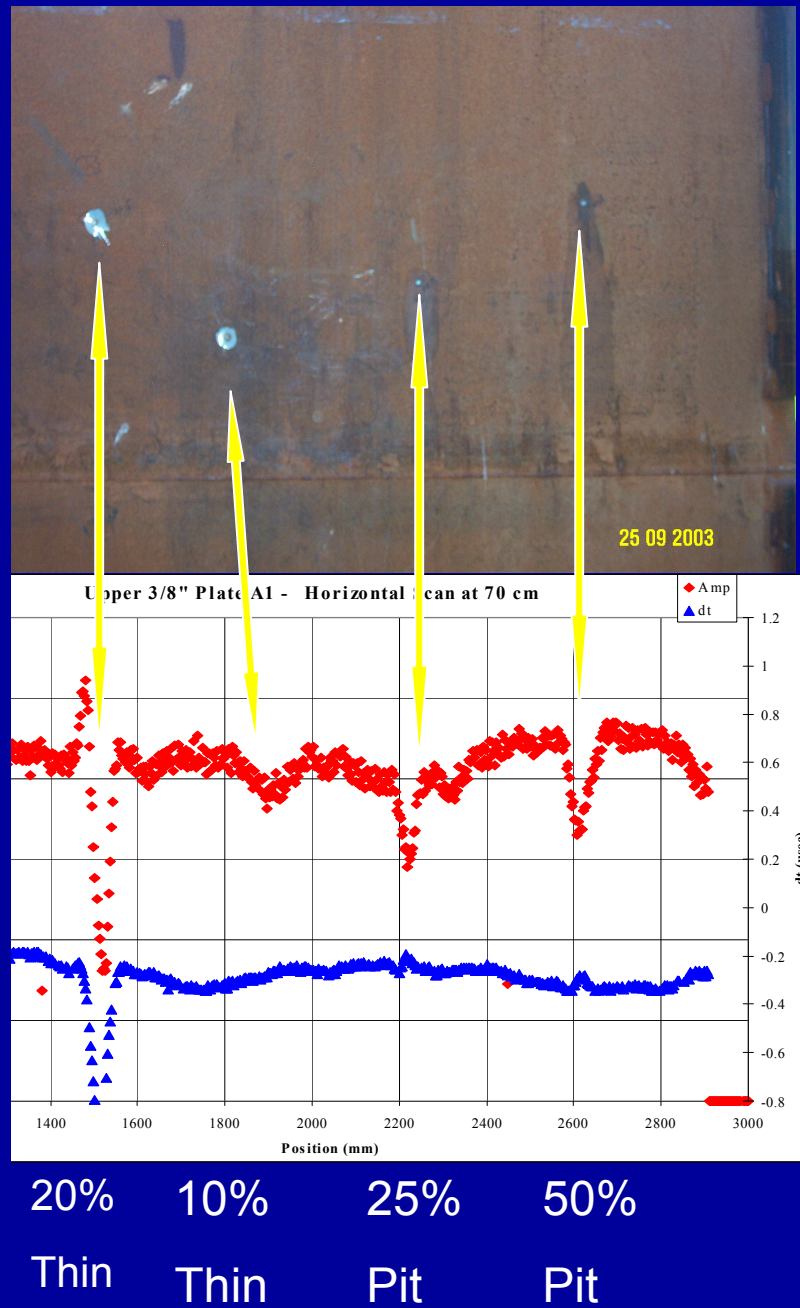


25 August 2009

[www.SonicSensors.com](http://www.SonicSensors.com)

12

# PNNL Blind Test Results



## Simple Data Interpretation

#	Feature	Depth	Size
B	Thinning	20%	4x5 cm
C	Thinning	10%	4x4 cm
D	PIT	25%	1cm dia
E	PIT	50%	1cm dia

# PNNL Blind Test Results

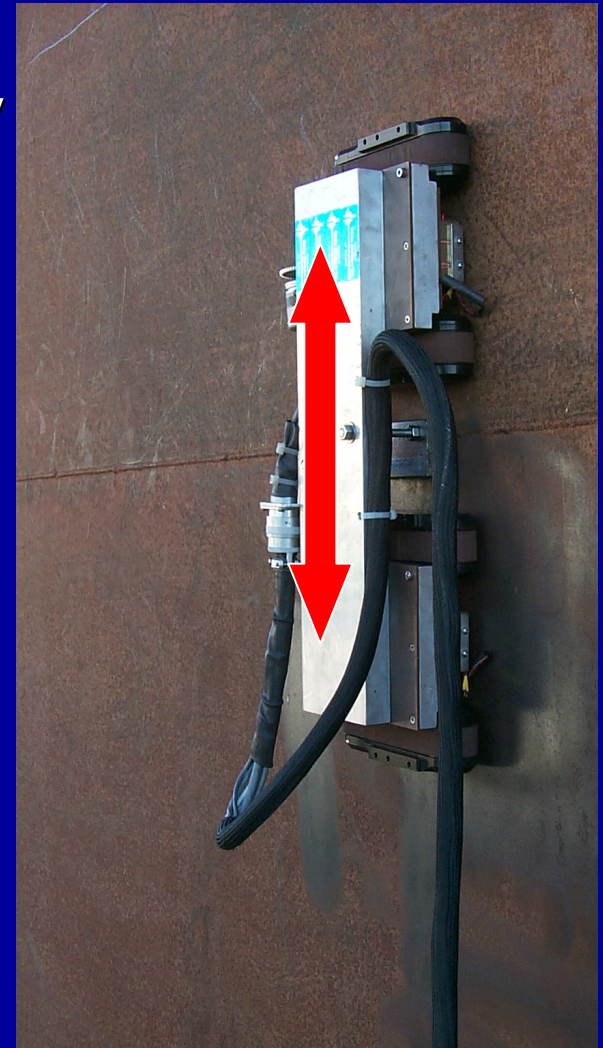
## Inspection Requirements

Feature	Reportable	Action Required
Pitting	25%	50%
Thinning	10%	20%

- ✓ All features were found.
- ✓ 25% pitting was clearly detected in all cases
- ✓ Thinning performance exceeded requirement
- ✓ Additional Grinding feature detected which was not known to be present until inspection was performed

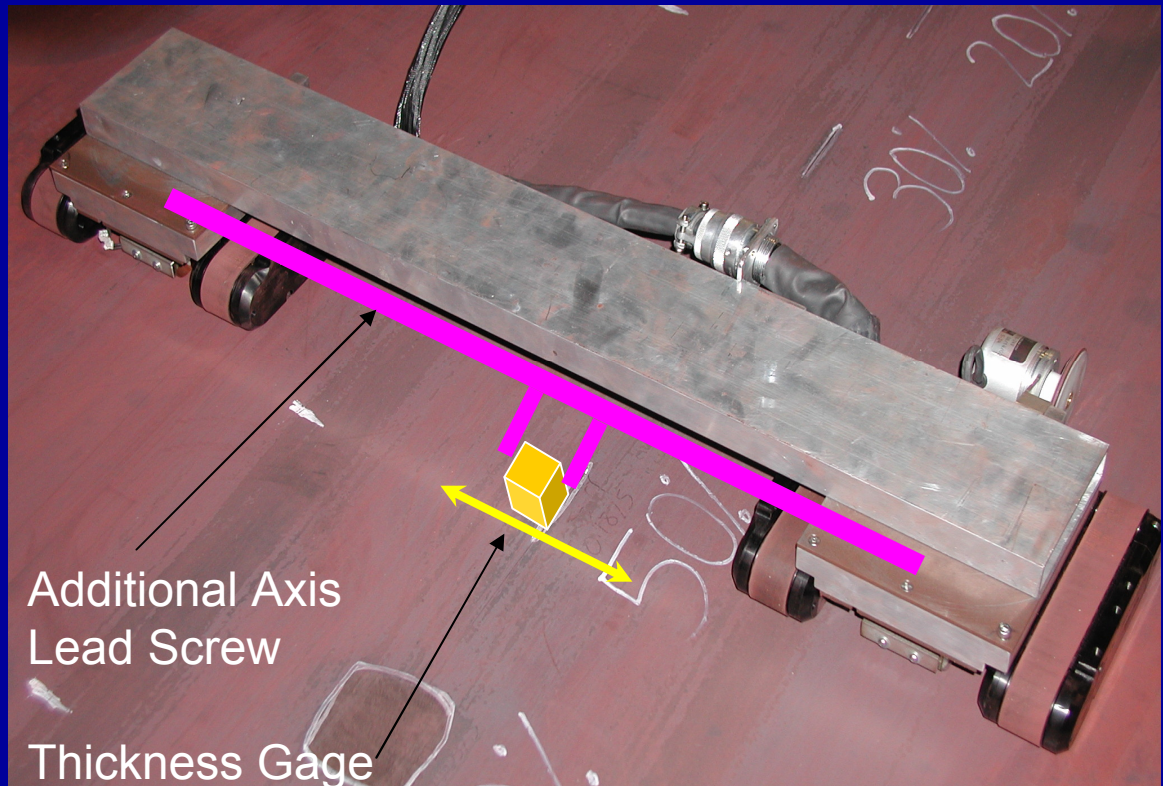
# 13" Swath Inspected at Scan Speed

- FAST – ECONOMICAL
- 2 Tractors propel and steer with great mobility
- Can drive over welds
- Horizontal Scans can be the longest – economical
- Constant elevation scans provide efficient repeatable mapping



# Add Thickness Gage for Quantification

- ❑ Screen with Lamb Wave
- ❑ Quantify with Thickness Gage “B” Scan
- ❑ Thickness Gage could be EMAT or Piezo



# Variant of this scanner has been used to inspect tanks



NOTE: Any Crawler should have a safety rope

# Tractor Treads

## Effectively Crawl over welds



- ❑ Welds can be inspected in through transmission.
- ❑ Consistency of weld determines resolution of inspection

# Crawler drives around curved bottom



Inspecting the curve as it travels



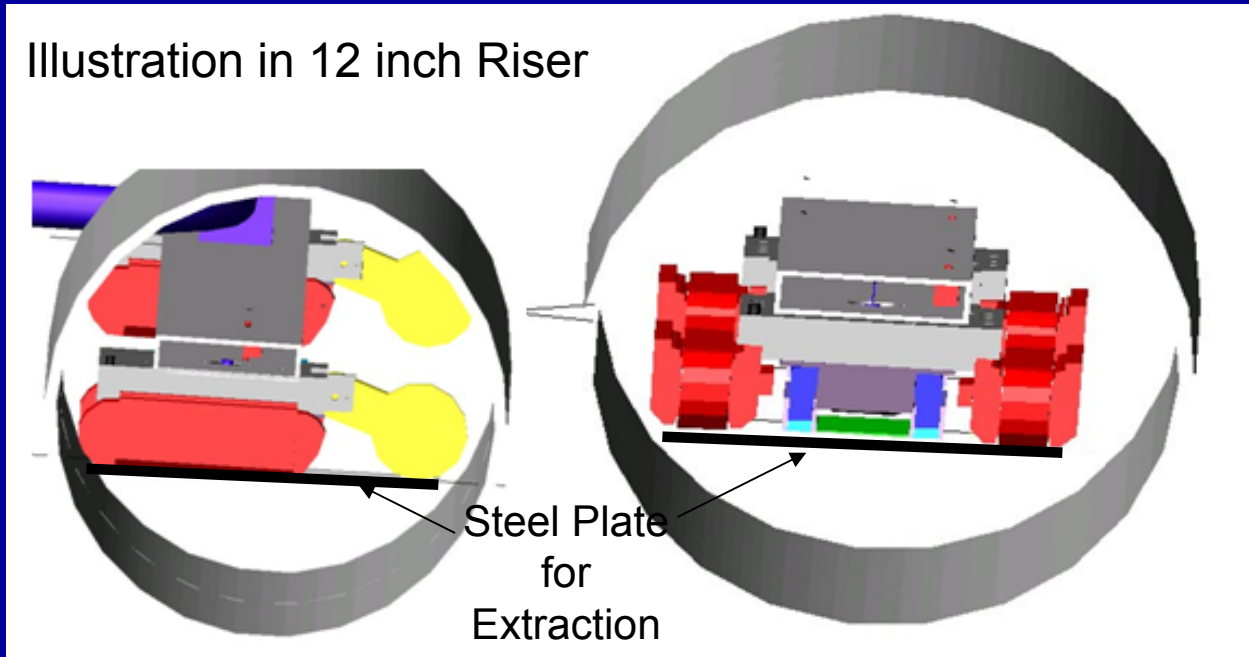
# Original Delivery Concept

- 1: Drive into Tank through Access Port
- 2: Rotate Treads
- 3: Scan large areas fast
- Super Maneuverability



# Deliver Tool on Steel Plate Through Riser

Illustration in 12 inch Riser



- ❑ Insert tool on a steel plate
- ❑ Tool drives off onto the tank wall
- ❑ Removed by driving crawler onto the plate
- ❑ Lift plate and crawler out of riser
- ❑ Magnetic crawler attachment only sticks to the plate
- ❑ Steel plate shields the magnetic attraction from the riser or other obstacles.

# Navigation Issue

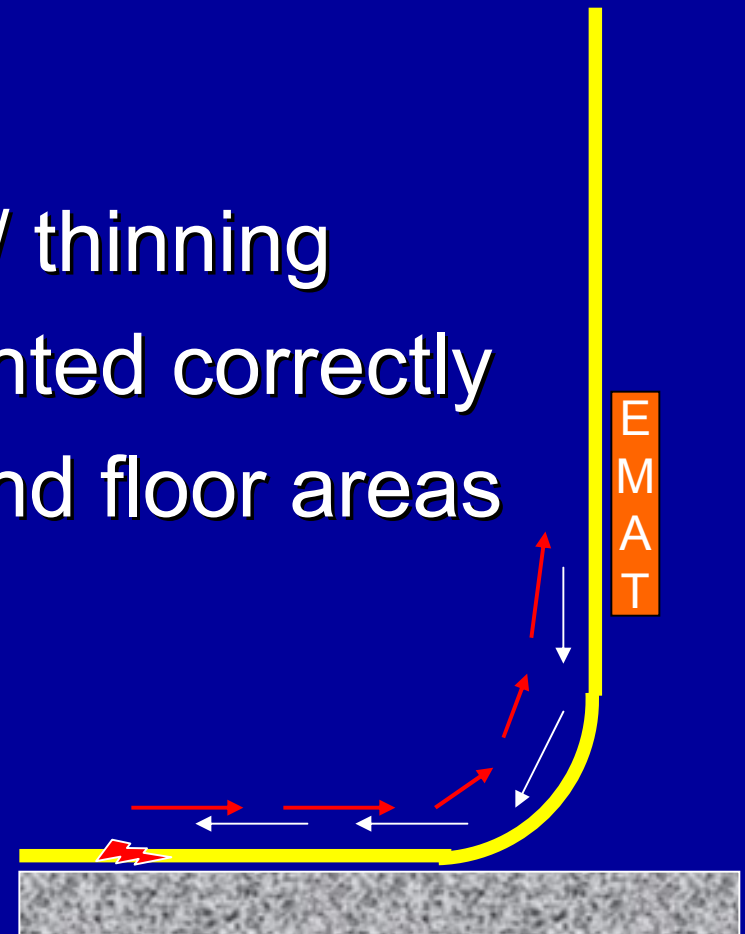
- Laser Elevation line to follow
  - Manual or Automatic line following
- Inclinator on crawler for driving straight
- Ultrasonic Range finder
  - Referencing tank top or bottom
- ?? To be determined

# Implementation Path

- Refine Scanner for accurate and repeatable navigation
- Integrate thickness gage or “P” scan onto crawler – Screen and Quantify
- Approve Equipment for annulus insertion
- Compose/Document Inspection Procedure
- Acceptance Test of Entire System and Procedure
  - Identify – Train – Qualify Inspectors
  - Certification of tool and inspectors
  - Performance Demonstration Test
- **Inspect Tanks**

# AXUS Tool for Inaccessible areas

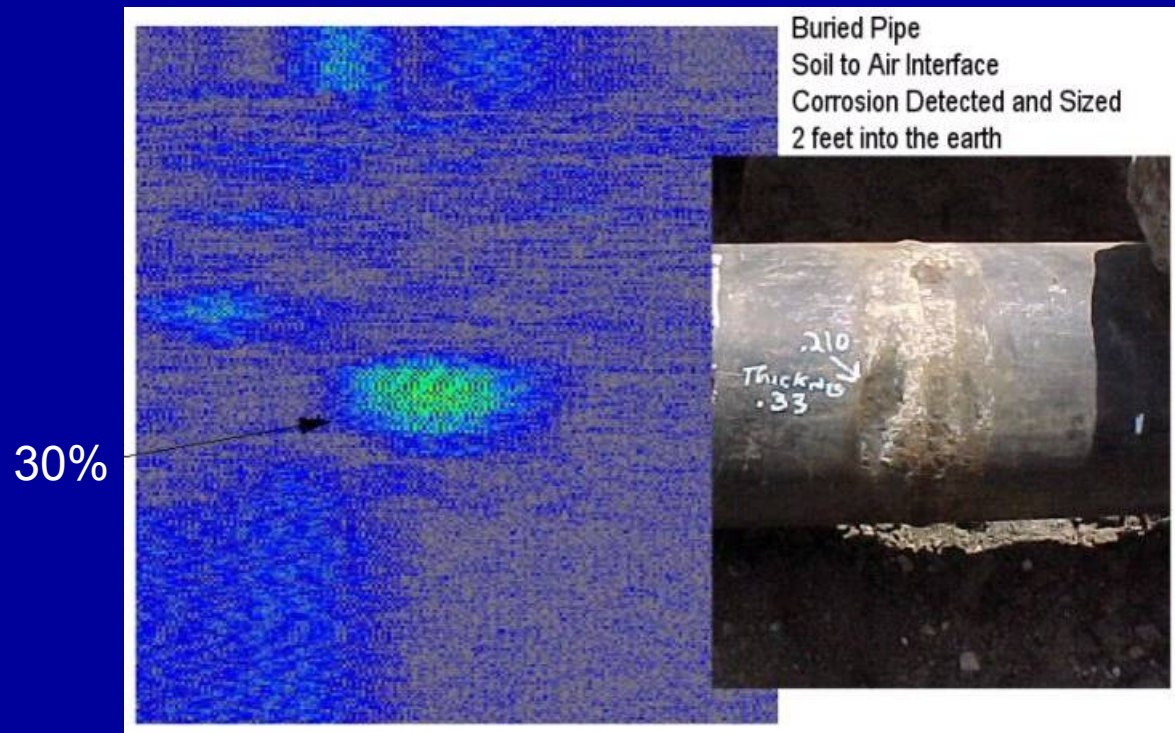
- Pulse Echo Mode
- Reflects from corrosion / thinning
- Detects cracking IF oriented correctly
- Application to knuckle and floor areas



# Pulse Echo

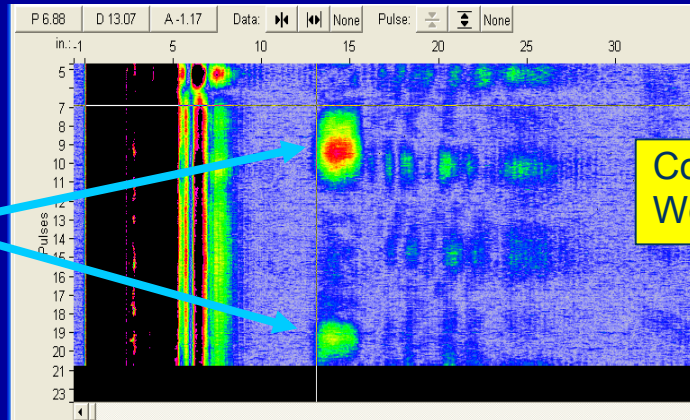
## Axial Guided Wave Inspection

- Acoustic Feeler Gauge
- Detect
- Image
- Quantify remaining wall



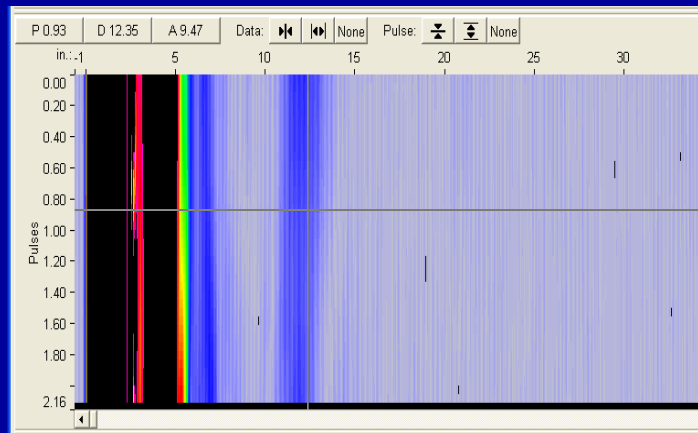
# Weld under a clamp

Corrosion  
in Weld



Corroded  
Weld

Clean  
Weld  
Scan

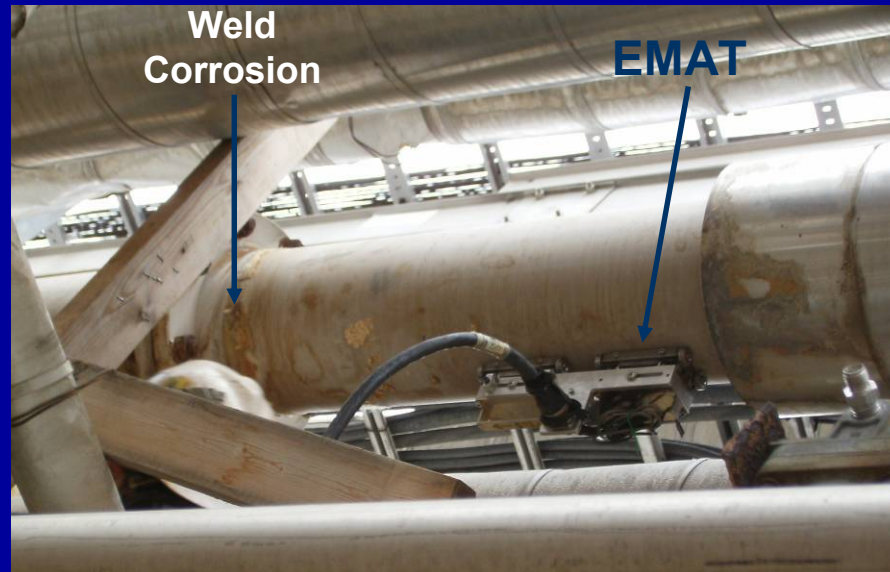
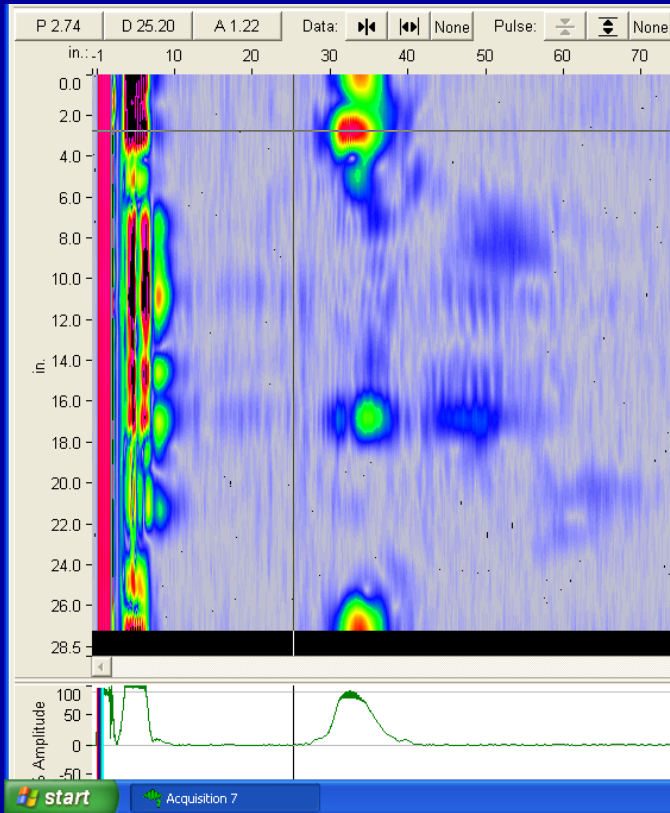


Good  
Weld



# Welds Under Insulation

## Ethanol Induced Corrosion in HAZ



Quantitative sizing is only possible with a complete characterization on similar geometry.

As would be required with PZT Shear wave scanning with complete access to the weld.

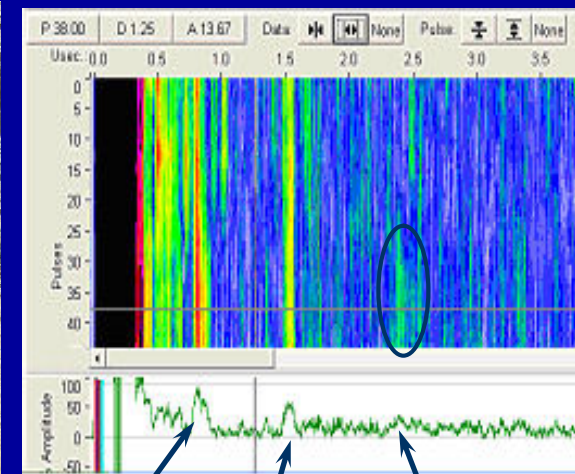
# AXUS Corrosion Detection

- Scanning the EMAT Axial Ultrasound Transducer
- Provides an IMAGE of the corrosion



Scan Here

Inspect Into the  
Earth



0.8' 1.5' 2.5'

Flange Weld Corrosion

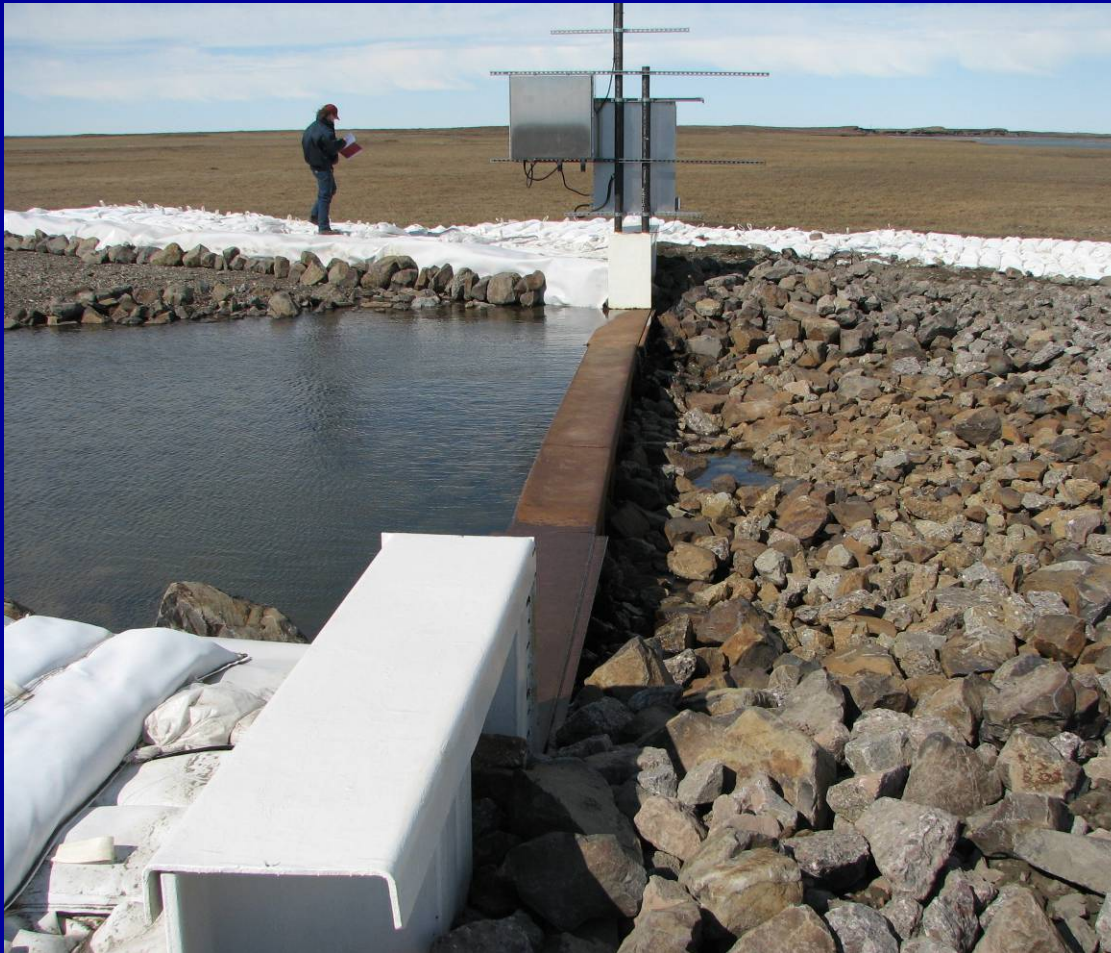
# Extend the Inspection REACH of a bell hole



Finds corrosion  
30%-60% deep  
(0.1 – 0.2" in 0.322 wall)

AXUS  
Scans  
around  
pipe here

# Depth of Buried Structures



Depth of corrugated steel dam extending into the earth was measured to be 4 meters deep.

25 August 2009

[www.SonicSensors.com](http://www.SonicSensors.com)

Corrosion in direct buried angle iron legs of Power Line Towers detected 2 m deep.



30

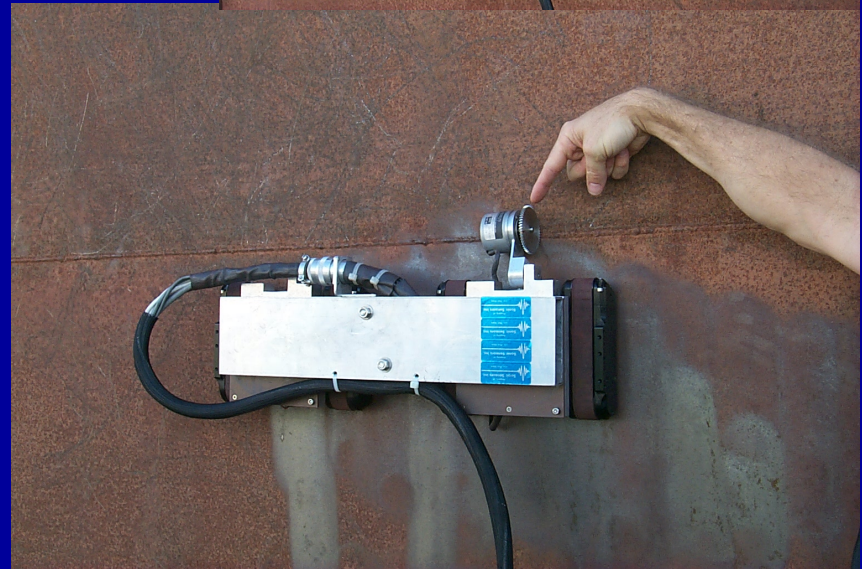
# EMATs offer many Possibilities

- No Couplant
  - No additional waste produced
- Easily Automated
  - Reliable transduction over rough surfaces
- High Speed Screening of Tank Wall
- Quantitative thickness mapping
- Inaccessible crack & corrosion detection

Summary: EMATs offer many possible solutions

# Inspection and Crawler are Ready

- Steering provided by independent tractor control
- Scan in any orientation to isolate and identify indications
- Encoder provides positional accuracy
- Compliments current “P” scan tool
- 1<sup>st</sup> Quick Survey
- 2<sup>nd</sup> Slow Quantification



# Pitting Thinning & Cracking



- Detects Pitting, and Thinning
- Relative Sizing: Finds the “Worst” area... FAST!
- Quantitative analysis performed by additional scan with a Thickness Gage